AN ECONOMIC ANALYSIS OF BROILER LITTER APPLICATION TO SELECTED ROW CROPS IN SOUTHWEST GEORGIA

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REFERENCE: Proceedings of the 2001 Georgia Water Resources Conference, held March 26-27, 2001, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, the University of Georgia, Athens, Georgia.

Abstract. The yield response to broiler litter application within an irrigated, intensive double-cropped rotation using conservation tillage practices is estimated for five row crops. Demand functions for broiler litter are derived for each row crop, and the total demand for broiler litter within a four-county area of Southwest Georgia is estimated. Results indicate, at prevailing prices, profit maximizing behavior would likely lead to litter application rates that exceed agronomic and environmental recommendations, especially for cotton.

INTRODUCTION

In 1999, Georgia broiler producers set the state record for birds produced for the seventeenth consecutive year; between 1992 and 1999 production increased 65% from 750 million birds to 1.24 billion (Georgia Agricultural Facts, 2000). Over this period broiler operations have spread from Georgia's northern Piedmont and Mountain areas to the Southern Coastal Plain. The issue of litter disposal has naturally accompanied this spread. One of the potential means of disposal is to apply the nutrient-rich litter to row crops.

Studies have indicated that litter is most effective as a fertilizer when incorporated into the soil soon after application (Gascho et al., 2000). Incorporating the litter into the sandy soils of Southwest Georgia upon application, however, is not consistent with the conservation tillage practices that are becoming popular in the area. The overriding objective of this paper is to evaluate the economic value of poultry litter from the perspective of a row crop producer using conservation tillage practices in Southwest Georgia. Specifically, this paper seeks to: (1) estimate the yield response of five row crops (cotton, peanut, millet, canola, and wheat) to poultry litter applications under an irrigated, conservation-tilled, intensive double-crop system in a sandy Coastal Plain soil, (2) determine the application rate of poultry litter that maximizes net returns to each crop, (3) estimate the amount of poultry litter produced in a four county area of Southwest Georgia, (4) estimate the amount of litter demanded by row crop producers in that area under current cropping patterns, and (5) estimate the size of subsidy needed to ensure all the poultry litter in the area is applied to the row crops.

METHODS AND MATERIALS

To determine the application rate of poultry that maximizes profits for a producer, an expression for net returns as a function of litter application rates is derived for each crop. A producer's net returns to the production of crop j (Π_j) are equal to the product of the price received for crop j (P_j) and total yield of crop j (Y_j), minus total costs incurred in the production of crop j (C_j). Net returns can be expressed on a per acre basis by simply dividing Π_j by the number of acres planted to crop j (A_j), as in Equation (1).

$$(1) \qquad \Pi_j/A_j = \pi_j = P_j \bullet y_j - \Sigma_i \, w_i \bullet x_{ij}$$

where π_j = per acre net returns to crop j
y_j = yield per acre of crop j
w_i = wage paid to input i
x_{ij} = use of input i per acre of crop j

Net returns per acre can be maximized with respect to input use by expressing per acre yield as a function of input levels such that $y_j = f(x_j)$. Maximization leads to the standard set of first order conditions:

$$(2) \qquad \partial\pi_j/\partial x_{ij} = P_j \bullet f_i - w_i = 0 \quad \forall\, i$$

and a matrix of second order derivatives that is negative semi-definite.[1] To determine the profit maximizing level of input use per acre, the system of equations represented by (2) is solved simultaneously for the

[1] Here f_i refers to the first derivative of the production function $f(x_{ij})$ with respect to input i.

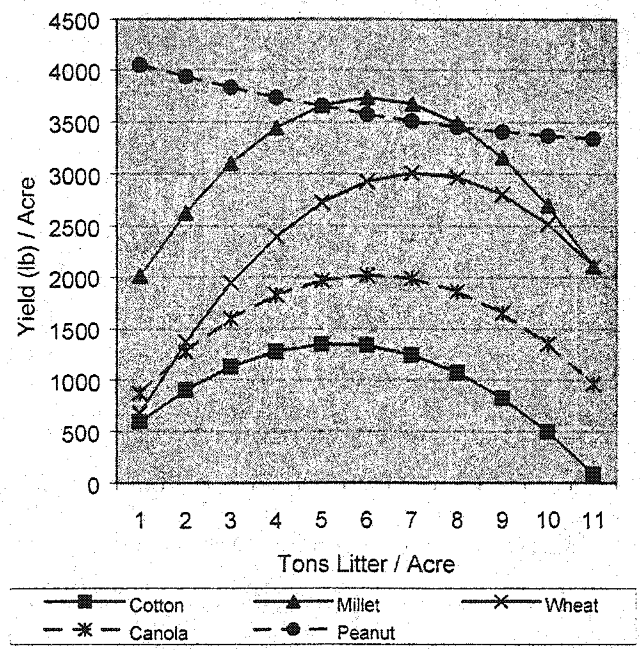

Figure 1. Crop response to poultry litter.

x_{ij}, leading to a set of input demand functions dependent on the price of the crop and the price of inputs, $x_{ij}^* = g(P_j,w_i)$. Within a given area, total demand for an input, X_i^*, may by calculated using Equation (3).

(3) $X_i^* = \Sigma_j A_j \bullet x_{ij}^*$

Data from a 4-year experiment (1996-1999) conducted at the Coastal Plain Experiment Station in Tifton, GA, were used to estimate the yield response of each crop to broiler litter application. The experiment examined the response of each crop within a double-cropped, irrigated 3-year rotation to four litter application rates (0, 2, 4 and 6 T/acre).[2] Broiler litter (broiler manure and wood shavings) was mechanically broadcast before each crop in a randomized complete block design with 4 blocks. For the initial summer crops in 1996, the litter was broadcast and the fallowed soil was disk-tilled and planted conventionally. For the duration of the 4-year experiment, winter crops were no-tilled and summer crops were strip-tilled with in-row subsoiling into residues remaining from the previous crop, following broadcasting of the litter treatments. No deep tillage was performed during the experiment. No commercial fertilizer was applied. Irrigation was applied for full yield potential by a lateral-move sprinkler system. All crops were grown with best management practices, except for the variables of broiler litter rate imposed.

The biological response of the five row crops – cotton, peanuts, canola, millet, and wheat – were estimated as a quadratic function of broiler litter application rate, as in Equation (4).

(4) $y_j = \alpha_j + \beta_j R_j + \gamma_j R_j^2$

for j = {cotton, peanut, canola, millet, wheat}
where R_j = Ton poultry litter / acre

Equation (4) was estimated by ordinary least squares. Table 1 presents the estimated parameter values for each crop. Figure 1 illustrates the estimated yield response of each crop.

Using the crop production functions from Equation (4), the per acre demand for poultry litter for each crop can be derived, as in Equation (5). Substituting in the estimated values of α, β and γ, the price of the crop, and the cost of poultry litter leads to an estimate of the profit maximizing litter application rate, R_j^*.

(5) $R_j^* = [(w_{litter} / P_j) - \beta_j]/(2*\gamma_j)$

For the analysis, the P_j for cotton, peanut, and wheat were taken to be the marketing year average price received by Georgia farmers, averaged over the four years of the experiment (1996-1999). Due to an absence of Georgia specific data, the price of canola was taken to be the U.S. annual average price, averaged over the four years of the experiment. As neither a

Table 1. Parameter Estimates for Equation (4)

Crop	α	β	γ	R^2	F-Stat
Cotton	593.7**	349**	-40**	0.85	38
	(65.1)	(52.1)	(8.3)		
Peanut	4052.7**	-119.8	4.9	0.08	0.6
	(370.7)	(296.6)	(47.2)		
Canola	873.7**	450.9**	-44.2*	0.69	14.3
	(164.4)	(131.6)	(20.9)		
Millet	2015.7**	678.1*	-66.9	0.39	4.1
	(458.3)	(366.8)	(58.4)		
Wheat	678.8	756.7	-61.4	0.35	3.6
	(660)	(528)	(84.1)		

** indicates p-value < 0.05; * indicates p-value < 0.10
standard errors appear in parentheses; n = 16 for all crops

[2] The rotation used was cotton-fallow, peanut-canola, millet-wheat. Each crop was grown in each year of the experiment.

Table 2. Price Received by Farmers for Each Crop

Crop	1996	1997	1998	1999	Average
Cotton[a]					
($/lb lint)	0.705	0.677	0.614	0.453	0.612
Peanut[a]					
($/lb)	0.297	0.303	0.303	0.272	0.294
Canola[b]					
($/lb)	0.129	0.113	0.103	0.078	0.106
Millet[a]					
($/lb)	0.064	0.052	0.044	0.040	0.050
Wheat[a]					
($/lb)	0.073	0.053	0.043	0.038	0.052

a: Source Georgia Agricultural Facts, 2000
b: Source NASS, Annual Agricultural Prices, 2000

Georgia nor a U.S. price for millet were reported for 1996-1999, the marketing year price Georgia farmers received for corn, averaged from 1996-1999, was used as a proxy for the price of millet. Table 2 presents the prices used in the analysis.

From the row crop producer's perspective the cost of using poultry litter as a fertilizer may be broken into three categories: (1) the price of the litter itself, (2) the cost of transporting the litter from the broiler house to the row crop fields, and (3) the cost of spreading the litter on the fields. Estimates of the price of poultry litter are difficult to find in the literature. One recent estimate of the price of poultry litter is \$5.25 T^{-1} (Vervoot and Keeler, 1999). The demand for litter was estimated for this price as well and two others, \$10.50 T^{-1} and \$21 T^{-1}.

Vervoot and Keeler (1999) estimate the cost of transportation to be \$0.044 T^{-1} $mile^{-1}$. At the same time, however, they argue that poultry litter is essentially a disposal concern for poultry producers rather than an acquisition concern for row crop producers. The poultry producer, therefore, is assumed to incur the transportation costs (i.e., transportation costs to the row crop producer = 0). Spreading costs were estimated by Givan and Shurley (1995) to be \$6.35 T^{-1}. The total cost of poultry litter, w_{litter}, to the row crop producer is equal to the price of the litter plus the spreading costs.

RESULTS AND DISCUSSION

Estimates of per acre demand of poultry litter for each crop, R_j^*, were derived using all three estimates of the price of litter, \$5.25 T^{-1}, \$10.50 T^{-1}, and \$21 T^{-1}. The total cost of litter (w_{litter}), therefore, was \$11.60, \$16.85, and \$27.35, respectively, for each price scenario. The demand estimates are presented in Table 3. These estimates pertain to an intensive double-crop, irrigated, conservation-till system in a sandy Coastal Plain soil, given the crop prices in Table 2.

Table 3. Estimated Poultry Litter Demand (T/Acre)

	R^*		
Crop	w = \$11.60	w = \$16.85	w = \$27.35
Cotton	4.13	4.02	3.80
Peanut[3]	0	0	0
Canola	3.86	3.30	2.18
Millet	3.33	2.55	0.98
Wheat	4.34	3.52	1.88

As Table 3 indicates, the amount of poultry litter demanded per acre by producers of each crop decreases as the total cost of the litter increases. Gascho et al. (2000) concluded, based on P application needs and concerns about NO_3-N movement in the soil, a rate of no greater than 2 ton/acre should be recommended when the application is repeated for each crop in the intensive, double-crop system. Under the \$11.60 and \$16.85 T^{-1} price scenarios, the per acre demand for litter exceeds agronomic recommendations on all crops except peanuts. Cotton and canola continue to demand more than 2 T/acre in the \$27.35 price scenario.

At these application rates, the question remains: how would the demand for poultry litter in a given area compare to the amount of litter produced in that area? As a preliminary investigation into this question, broiler litter production within a contiguous four-county area in Southwest Georgia was estimated and compared to the litter demand estimates. The counties represented in this area are Baker, Calhoun, Colquitt, and Mitchell.

The amount of broiler litter generated within a given area may be expressed as a function of the number of broilers residing in that area. A broiler produces an estimated 3.22 lb of litter during its 10 week life-cycle (Perkins et a., 1964), of which approximately 2.49 lb is manure (Gascho, 2000). The total lb of litter produced within a given area, then, is 3.22 times the number of broilers raised in the area.

In 1997, these four counties sold 48.3M broilers (Census of Agriculture, 1997). Assuming all of these birds spent the entirety of their life-cycle within these four counties, this translates into 77,800 tons of broiler

[3] Peanut demand is zero under any price because the estimated β_j for peanuts is negative – litter applications decrease peanut yield.

Table 4. Litter Produced and Crop Acreage, 1997

County	Litter (1,000 T)	Irr. Cotton[a] (Acre)	Irr. Wheat[a] (Acre)
Baker	6.6	10,592	830
Calhoun	8.2	8,876	921
Colquitt	12.5	18,427	498
Mitchell	50.5	14,818	495
Total	77.8	52,713	2,744

a: *Source* Census of Agriculture, 1997

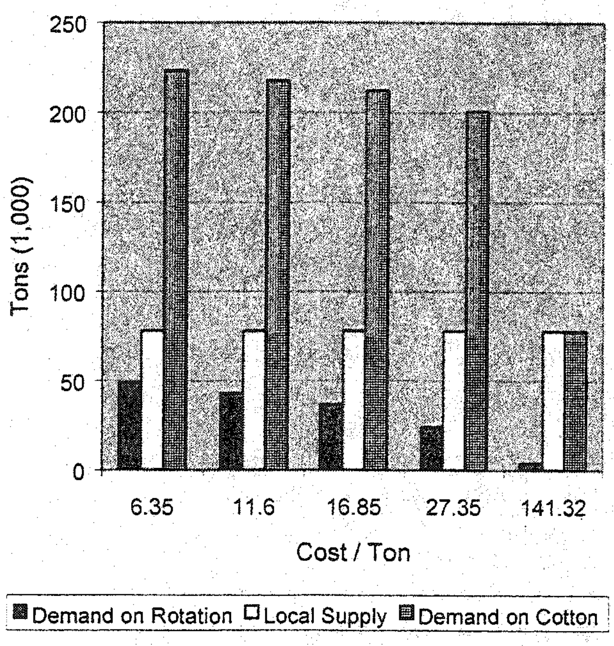

Figure 2. Tons of broiler litter demanded within 4 counties.

litter produced in 1997. Table 4 breaks the litter production down by county and also provides estimates of the number of acres of irrigated cotton and wheat within each county in 1997.[4]

If all 2,744 acres of irrigated wheat are assumed to be planted to the intensive, double-cropped system described above, total demand for broiler litter within the four-county area would be approximately 42,992 tons, when $w_{litter} = \$11.60\ T^{-1}$.[5] Supply of broiler litter within the counties would exceed litter demand on the rotation examined. However, if the demand estimates hold for irrigated cotton outside of the rotation as well, the four counties demand for broiler litter on irrigated cotton acreage would far exceed the local supply at each cost level considered. In fact, cost of broiler litter to the producer would have to reach \$141.32/ton to eliminate the excess demand within the four counties. Figure 2 illustrates these results.

How could the cotton growers meet this excess demand? With spreading costs of \$6.35/ton and litter price of \$5.25/ton, it would be profitable for the cotton growers of Baker, Calhoun, Colquitt and Mitchell Counties to purchase all of the local broiler litter *and* to transport all 122,800 tons of litter generated in Lumpkin, White and Hall Counties. The total cost of the poultry litter from the northern counties would be approximately \$27.35/ton, \$10.50 of which would be to transport the litter 240 miles.

CONCLUSIONS

Broiler litter is a valuable source of nutrients for cotton, wheat, millet, and canola planted within an intensive, double-cropped, irrigated system. The litter demand functions derived in this paper predict profit maximizing row crop producers would apply litter at rate in excess of agronomic and environmental recommendations when the total cost to the producer is below \$27.35/ton. This conflict is especially acute for cotton production – the total cost of broiler litter to the cotton producer would have to exceed \$100/ton to induce an application rate of 2 T/acre. Additional research is necessary to determine if the estimated demand functions would hold for irrigated cotton outside of the rotation evaluated in this paper. Furthermore, the effect of price on the demand for, and expected application rates of broiler litter on all crops, throughout the state, should be carefully considered when contemplating publicly-funded market interventions that affect the costs associated with the use of poultry litter.

REFERENCES

Gascho, G. J., R. K. Hubbard, T. B. Brenneman, A. W. Johnson, D. R. Sumner, and G. H. Harris. 2000. "Value, Soil, and Pest Effects of Broiler Litter in an Irrigated, Double-Cropped, Conservation-Tilled Rotation," in review.

Givan, W. and D. Shurley. 1995. *Crop Enterprise Cost Analysis* (Ag Econ 94-010-s Revised). Athens, GA: Cooperative Extension Service, The University of Georgia.

[4] Acreage of millet and canola were not available.

[5] Total demand within the area is calculated using Equation (3), assuming 2,744 acre of wheat, cotton, millet, and canola were planted.

Perkins, H. F., M. B. Parker, and M. L. Walker. 1964. *Chicken Manure – Its Production, Composition, and Use as a Fertilizer* (Bulletin 123, 24 pp.). Athens, GA: Georgia Agricultural Experiment Station.

US Department of Commerce. 1997. 1997 Census of Agriculture. Georgia State and County data.

Vervoot, R. W., and A. G. Keeler. 1999. "The Economics of Land Application of Fresh and Composted Broiler Litter with an Environmental Constraint," *Journal of Environmental Management*, Vol. 55, pp. 265-272.